Periodic Classification of Elements

Synopsis

1) Periodic Trends in properties— Atomic Radius, Types of Atomic Radius, Ionic radius
2) Ionisation Enthalphy, Electron gain Enthalphy& Trends
3) Electro negativity, oxidation states, chemical reactivity
4) Introduction, Mendeleev periodic table, Moseley's law

*At present maximum 92 elements were available in elemental form.

1. Doebereiner's law of triads:

a. He arranged similar elements in groups of three and showed that their atomic weigh were either nearly same or the atomic weight of the middle element was approximately the arithmetic mean of the other two. These groups of three elements were called Doebereiner's triads

b. Also the properties of the middle element were in between those of other two members.

E.g.1: **Element** *Li* *Na* *K*

Atomic wt. 7 23 39

Mean of atomic masses $= \frac{7+39}{2} = 23$

E.g. 2: Element CI Br I

Atomic wt. 35.5 80 127

Mean of atomic masses $= \frac{35.5+127}{2} = 81.25$

E.g. 3: Element Ca Sr Ba

40 88 137

Mean of atomic masses $= \frac{40+137}{2} = 88.5$

2. Newland Octaves

According to Newland law of Octaves "If the known elements are arranged in the increasing order of their atomic weights, then the 8th element had properties similar to those of first element" .This law is true only for the elements up to calcium.

Li	Be	B	C	N	O	F
Na	Mg	AI	Si	P	S	Cl
K	Ca					

3. Lother Meyer plotted the physical properties such as atomic volume, melting point and boiling point against atomic weight and obtained a periodically repeated pattern. Lother Meyer calculated the atom volumes of known elements as the ratio of molecular weight and density.His observations are:

a) Alkali metals having the largest atomic volumes occupy the maxima of the curve.

b) The alkaline earth metals (Mg, Ca, Sr, Ba) occupy the mid point positions on the descending portions of curve.

c) Halogens occupy position on ascending portions of the curve before inert gases.

d) The transition elements occupy minima of the curve.

4. **Mendeleev's Periodic Law:** The physical and chemical properties of the elements are periodic functions of their atomic weights.

5. Mendeleev's periodic table is short form of periodic table. In this the elemens arranged in the increasing order of atomic weights by taking their properties in to consideration

6. Mendeleev observed that elements with similar properties have

i) Almost have same atomic weight.

E.g.: Fe (56), Co (59), and Ni (59)

ii) Atomic weights increasing constantly

E.g.: K (39), Rb(85), Cs(133)

7. There are nineVertical columns called groups and seven horizontal rows are called periods.
8. The first three periods are short periods and remaining are long periods. Each long period has 2 rows of elements or 2 series of elements'
9. Groups I to VII are divided into subgroups as A and B group.VIII Group consists of threesets of three elements each called as transition triads. They are

   i) Iron, Cobalt and Nickel

   ii) Ruthenium, Rhodium and Palladium

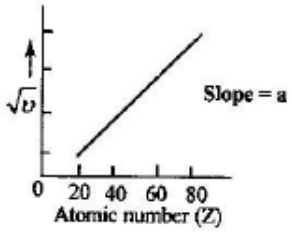
   iii) Osmium, Iridium and Platinium
10. Mendeleev left gaps for missing elements, called 'eka' elements. Eka- boron was now discovered as Scandium, Eka-silicon as Germanium and Eka -aluminum as Gallium.
11. Mendeleev corrected the atomic weights of Beryllium, Indium, Uranium and Osmium by using corrected valency of elements.

    Atomic Wt. = Equivalent Wt. x valency. .
12. The increasing order of atomic weights is not followed in certain pairs of elements: a) Ar-K b) Co-Ni c) Te-I and d) Th - Pa .These pairs are called anomalous pairs.
13. Zero group elements were not known at the time of Mendeleeff cand later introduced by Ramsay and Rayleigh.
14. Moseley discovered the atomic numbers from X-ray spectra of elements by bombarding the elements with cathode rays and the elements emitted respective X-rays of characteristic frequency.

ii) Atomic number 'Z' can be related to frequency of the X-rays emitted by Moseley equation.

$\sqrt{v} = a(Z - b)$ Where a, b are constants for an element. Higher the atomic number greater is the frequency of characteristics x-rays.

iii) A plot of against Z gives a straight line.



Modern periodic table, Classification of elements into 4 blocks and 4 types, Nomenclature of elements with atomic numbers Z>100

1. **Modern Periodic Law:** Physical and chemical properties of the elements are periodic functions of their atomic numbers and electronic configuration.
2. Modern periodic table or the long form of periodic table is based on the electronic configurations of the elements. It is a graphical representation to Aufbau principle.
3. It consists of 18 groups and 7 periods.
4. **Periods:** Generally every period starts with an Alkali Metal and ends with Noble gas.

   a. First period contains 2 elements (H,He) called shortest period. (1s orbital is filled)

   b. Second period contains 8 elements (Li to Ne) called, 2s, 2p orbital are filled. (I short period)

   c. Third period contains 8 elements (Na to Ar) called II short period. (3s, 3p orbitals are filled)

d. 4th period contains 18 elements (K to Kr) called I long period. (4s, 3d, 4p orbitals are filled) Elements from Sc to Zn (Z= 21 to 30) are placed in 4th period are called first transistional series or 3d series.

e. 5th period contains1 8 elements (Rb to Xe) called II long period. (5s, 4d, 5p orbitals are filled) Elements from Y (Z=39) to Cd (Z=48)] placed in 5th periodare called 2nd Transition series.

f. 6th period contains32 elements (Cs to Rn) called longest period. (6s, 4f, 5d, 6p orbitals are filled) Elements from La (z=57), Hf (Z=72) toHg (Z=80) are placed in 6th period.is3rd transition series.

14 elementsCe (Z=58) to Lu (Z=71) called Lanthanoids belong to 6th period and III B group.

g. 7th period is an incomplete period (7s, 5f, 6d, 7p orbitals are filled)

14 elements, Th (Z=90) to Lr (Z=103) called Actinoids belong to 7th period & III B group.

Period	First group element	Electronic configuration	Last group element	Electronic configuration
1	H (Z= 1)	$1s^1$	He (Z = 2)	$1s^2$
2	Li (Z = 3)	$[He]2s^1$	Ne (Z= 10)	$[He]2s^22p^6$
3	Na (Z = 11)	$[Ne]3s^1$	Ar (Z = 18)	$[Ne]3s^23p^6$
4	K (Z = 19)	$[Ar]\ 4s^1$	Kr(Z=36)	$[Ar]3d^{10}4s^24p^6$
5	Rb (Z = 57)	$[\ Kr]5s^1$	Xe(Z=54)	$[Kr]4d^{10}5s^25p^6$
6	Cs (Z = 55)	$[Xe]6s^1$	Rn(Z=86)	$[Xe]4f^{14}5d^{10}6s^26p^6$
7	Fr (Z = 87)	$[Rn]7s^1$	-	-

4. Groups

a. Long form of the periodic table comprises of 18-vertical columns IA, IIA, IIIB, IVB, VB, VIB, VIIB, VIIIB (includes three vertical columns), IB, IIB, IIIA to VIIA, O groups which are numbered 1-18 respectively as per IUPACsystem.

b. VIIIB groups includes three vertical columns of

Fe	**Co**	**Ni**
Ru	**Rh**	**Pd**
Os	**Ir**	**Pt**

Group	Name	Outer Electro configuration
IA	Alkali metals	ns^1
IIA	Alkaline earth metals	ns^2
IIIA	Boron family	ns^2np^1
IVA	Carbon family	ns^2np^2
VA	Nitrogen family or Pnycogens	ns^2np^3
VIA	Oxygen family or chalcogens	ns^2np^4
VIIA	Halogens	ns^2np^5
VIII or Zero	Noblegases	ns^2np^6
	except for He	

* Elements of third period are called typical elements.

* Elements beyond Uranium (z>92) are called Transuranic elments.

5. IUPAC Nomenclature for Elements with Z>100

Atomic numbers	Systematic	IUPAC
101	Unnilunium (Unu)	Mendelevium (Md)
102	Unnilbium (Unb)	Nobelium (No)
103	Unniltrium (Unt)	Lawrencium (Lr)
104	Unnilquadium (Unq)	Rutherfordium (Rf)
105	Unnipentium (Unp)	Dubnium (Db)
106	Unnilhexium (Unh)	Seaborgium (Sg)
107	Unnilseptium (Uns)	Bohrium (Bh)
108	Unniloctium (Uno)	Hassium (Hs)
109	Unnilennium (Une)	Meitnerium (Mt)
110	Ununnilium (Uun)	Darmstadtium (Ds)

6. Classification of elements on the basis of their Electronic Configuration

Elements are classified into four blocks basing on the orbital into which the differentiating electron enters.

a) s-Block Elements

b) p-Block Elements

c) d-Block Elements

d) f-Block Elements

s - Block Elements

a. Elements of IA, IIAgroups arecalled s-block elements as differentiating electrons enter into s- orbital of valency shell.

b. Their general electronic configuration is **ns1-2.**

c. They show fixed oxidation states i.e +1 by IA and +2by IIa group elements.

d. Most of these are active metals and form ionic substances (except lithium and beryllium).

e. All these are powerful reducing agents.

f. They have relatively low density, M.P's and B.P's.

g. Their ions are colourless and diamagnetic.except lithium and beryllium, remaining impart characteristic colours in the flame test.

p - Block Elements

a. Elements of IIIAtoVIIA and Zero groups are called p-block elements as differentiating electrons enter into p- orbital of valency shell.

b. Their general outer shell configuration

c) p-block contains almost all non-metals and all metalloids alog with some metals.

d) Most of the p-block element compounds are covalent.

e) Most of these (VIA $VIIA elements) are oxidising agents

f) All gaseous elements except H and He are in p-block only.

* He is a s-block element placed in p-block.

g. These elements show variable oxidation states except Al, F.

d- Block Elements

a. Elements of IIIB, IVB, VB, VIB, VIIB, VIIIB (includes three vertical columns), IB, IIB groups are called "d-block elements" as the differentiating electron enters the **d-orbital of penultimate shell.**

b. The general electronic configuration of d-block elements is

$(n-1)d^{1-10}ns^{1or\,2}$ (n =3, 4, 5, 6)

c. These elements are placed between s-block and p-blockfrom 4th period onwards as

1)1st Transition series (3d series) Sc (Z=21) to Zn (Z=30)

2)2nd Transition series (4d - series) Y (Z=39) to Cd (Z=48)

3)3rd Transition series (5d - series) La (Z=57), Hf (Z=72) to Hg (Z=80)

4)4th Transition series (6d - series) is an incomplete series.

d) Most of these are hard metals with high density, M.P's and B.p's.

e) These elements form ionic and co-ordinate covalent compounds.

f) They are all solids, except Hg which is a liquid at room temperature.

g) They show variable oxidation states and their comman oxidation state is +2.

h) They form alloys, complexes and interstitial compounds.

i) They form coloured ions and show paramagnetism &catalytic activity

j) Os and Ru show highest.oxidation state +8.

Ac belongs to d-block (IIIB, VII period).

f-block Elements

a. Elements of Lanthanides and Actinides are called f-block elements as differentiating electron enter into f-sub shell of anti penultimate i.e., (n-2) shell,

b. Their general electronic configuration is $(n-2)f^{1-14}(n-1)d^{1orO}ns^2$ (n = 6or7).

c. These are placed below the periodic table in two rows as 4f series and 5f series.

d. The properties of 4f-series elements**Ce (58) to Lu (71)** are similar to Lanthanum hencearecalled Lanthanides. These are alsocalled rare earths.

e. "La" and Lanthanides belong to 6th period and IIIB Group.

f. The properties of 5f-series elements **Th (90) to Lr (103)** are similar to Actinum henceare called Actinides. These are alsocalled radioactive elements.

g. Actinum andActinides belong to 7th period and III B group.

h. Their properties are similar to d-block elements

i. They show variable oxidation states and their comman oxidation state is +3.

Classification Based On Chemical Properties

All the elements are divided into four types on the basis of their chemical properties and electronic configuration.

1. Inert Gases

a.He, Ne, Ar, Kr, Xe and Rn belongs to "0" group in the periodic table are called **Inert Gas Elements**.

b. Except He ($1s^2$), all the other elements have ns^2np^6 outer electronic configuration.

c. these are chemically inert due to stable ns^2np^6 (octet) configuration.

d. They are also known as rare gases, aerogens, Noble gases or monoatomic gases

. e. atmospheric air contain 1%Noble gases by volume.

f. These are placed at extreme right side of the periodic table.

Representative elements or normal elements

a. Atoms of these elements have last shell only incompletely filled. i.e ultimate shell.

b. Excluding "0" group, remaining s and p block elements (IA, IIA, IIIA, and IVA, VA, VIA, VIIA) belong to this type.

c. Their general outer electronic configurations ns^{1-2} np^{1-5}.

d.Metals, non-metals and metalloids are present in representative elements.

e. Atoms of these elements involve in chemical bonding by losing, gaining or sharing of electrons **to attain nearest inert gas configuration.**

Transition elements

a. Atoms of these elements have last two shellsas incompletely filled. i.e. ultimate shell and penultimate shell.

b. Atoms of these elements have incompletely filled or partly filled d-orbitals either in elementary state or in one of stable oxidation state.

c. Their general electronic configuration is $(n-1)d^{1-9}ns^{1or2}$.

d. Except IIB, all d-block elements belong to this type but elements of II Bgro (Zn,Cd, Hg) are only d-block but not transition elements as their atoms & ions contain competely filled d-orbitals

e. due to Small size, High nuclear charge andUnparied electrons in d-orbitals.

Transition elements show the following characteristic properties

i. Variable Oxidation states

ii. Formation of coloured ions in solution due to d-d- transition

iii. Formation of metal complexes

iv. Paramagnetism

v. Catalytic activity (Ni used as a catalyst in Hydrogenation of oils.Fe in Haber's process)

vi. High M.P., B.P and densities.

vii. Good conductors of heat and electricity (Ag is the best conductor electricity)

viii. Alloy formation.

Inner Transition Elements

a. Atoms of these elements have last three shells as incompletely filled. i.e. ultimate shell , penultimate shell and antepenultimate shell.

b. The f-block elements are called inner transition elements.

c. Their general electronic configuration is $(n-2)\,f^{1-13}(n-1)d^{1-0}ns^2$

d. These elements have similar physical and chemical properties as their last two shells have similar configuration

(**E.g**. - their common oxidation state is +3).

e. Both Lanthanides and Actinides belong to this type.Lanthanides are rare earths and actinides are mostly synthetic.

f. The elements after Z=92 are called transuranic elements.